SCIENCE

VOL. LXXII | FRIDAY, SEPTEMBER 26, 1930 | No. 1865

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS
New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.
Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

THE ETHER CONCEPT IN MODERN PHYSICS[1]

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I HAVE felt it would be safe to assume that the ether concept is a subject of interest to the workers in all scientific fields. As a matter of fact, it must be a matter of concern to all thinking people, since it has to do with some of the greatest of those forces of nature upon which depend the comfort, the happiness and, indeed, the very existence of the human race.

It is not here implied that a knowledge of this or, for that matter, of any physical theory is essential to man's existence; but it will be conceded, I think, that knowledge of this sort may contribute greatly to his comfort and happiness.

To have one's interest in this question aroused it would perhaps be sufficient to be reminded that the ether theory attempts among other things to explain the machinery by means of which heat and light are transmitted through regions devoid of ordinary matter—the radiant energy, for example, which comes to us from the sun across more than ninety millions of miles of empty space. It is, of course, this unbroken stream of energy which pouring upon the surface of the earth makes possible here all the varied forms of life, and the study of life, together with its conditions and environments, is directly or indirectly the ultimate objective of all branches of physical and biological science.

The first use of the ether concept is shrouded in the haze of the fragmentary records of antiquity. In more recent times, for which the records are more complete, it has had a strange and checkered history and for centuries in scientific discussions it has been a subject of bitter controversy.

The theory that space is filled by an all-pervading medium having properties unlike those of ordinary matter was for a time quite generally accepted. Later on, it was rejected and all but forgotten. It was afterwards revived and strengthened and brought

[1] Address of the president, forty-fourth annual meeting of the Iowa Academy of Science, Ames, Iowa, May 2, 1930.

to a high place in scientific thought—only once more to fall into serious question. At the present time it struggles for existence but it shows signs of surviving and gives promise of continuing for a long time to come. It is doubtful if man in his thinking can ever dispense with it altogether.

To be sure, there are scientists of to-day, as there always were in the generations past, who profess to have no need for the ether hypothesis; but curiously enough there is usually collateral evidence that these same philosophers make use of it in their thinking, however studiously they may avoid any reference to it in their speech.

The widely accepted pronouncement that "truth crushed to earth will rise again" carries with it, as a sort of corollary, the implication that in man's search for truth a recurring theory must have in it the elements, at least, of conformity to fact. The very circumstance of its return, after temporary overthrow, to a high place in scientific thought argues for some sort of relationship to truth.

The astounding history of the ether concept—of its rise and fall, its resurrection and its continuing power—is probably without parallel in the records of the scientific world.

I invite you to a brief consideration of the ether concept, directing your attention particularly to its rise and development, to some of its shortcomings and to its more important implications.

The writings of St. Thomas Aquinas, whom we may regard as the spokesman of the religio-scientific thinkers of the thirteenth century, indicate a general acceptance at that time of the Ptolemaic system of astronomy. This system was founded upon the assumption that as "man was the object of creation, so the earth was the center of the universe, and around it revolved concentric spheres of air, aether, and fire—'the flaming walls of the world'—which carried round the sun, stars and planets."[2]

This early history is mentioned partly in preparation for that which follows and partly to show that an ether concept was in use at this period. It should be noted, however, that this "aether" is not an all-pervading medium. It composes one of the concentric spheres and is, therefore, in form a spherical shell.

Two hundred years later, after the work of Copernicus and Galileo had overthrown the geocentric theory of the universe, and the hypothesis of the crystalline spheres as the carriers of celestial bodies had been abandoned, it became necessary to find a way to account for the motion of the planets.

The first conspicuous attempt to do this was made in the middle of the seventeenth century by Descartes in his celebrated vortex theory. This theory assumes that interplanetary spaces are occupied by a plenum which is filled with great vortices. In these plenum vortices the planets and their satellites are carried. The sun is at the center of an immense vortex which carries the planets, and each planet the center of another vortex accounting for the motion of the planet's satellites. Thus the plenum is formed into vortices of varying size and velocity, and it is assumed that a celestial body in any such vortex, being slower and less subject to centrifugal action, is forced toward the vortex center.

Descartes' theory is not considered comparable in importance with those of Ptolemy or Copernicus, largely perhaps because it apparently led to no new discoveries; but it was rated of considerable importance in philosophy because it constituted an attempt at a mechanical explanation of the universe. It is interesting to note that it survived for a century or more in advanced scientific thought and teaching, not alone in France, but in England and America as well. It is recorded that an English translation of Descartes' treatise was in use as a text-book in Yale College as late as 1743—long after the publication of Newton's work which pointed out the inconsistencies of the vortex theory.

As we have seen, the first important use of the ether concept was in an attempt to account for planetary motion and to explain the structure of the universe. It was next employed by Hooke and Huygens toward the end of the seventeenth century (1678) to explain the transmission of light. Descartes too, as a matter of fact, had held that light is a pressure transmitted through his plenum of space.

Thus we see that again the assumption is made that there is a non-material medium which fills all space, the medium this time being particularly characterized by the property that luminous bodies have the power to set up wave motion within it. This is the luminiferous ether, and under this ether theory light is a wave phenomenon.

Newton professed to be unable to accept the theory of the luminiferous ether on this basis, chiefly because he believed it failed to explain in a satisfactory way the fact that light travels in straight lines. He taught that straight line motion is natural to moving *bodies*, and it is easy to understand the appeal of the corpuscular theory to him on this score. He says in Query 29 of his "Opticks," "Are not the Rays of Light very small Bodies emitted from shining substances? For such Bodies will pass through uniform mediums in right Lines without bending into the Shadow which is the nature of the Rays of Light."

The seventeenth century witnessed a conflict between these two theories of light. "Newton from facts then known balanced the arguments for and against each

[2] Dampier-Whetham, "A History of Science," p. 96.

theory, and hesitatingly decided in favor of the emission theory, while on the continent his great contemporary Huygens advocated the wave theory."

Concerning this conflict S. P. Langley said:

> These two great men, then, each looked around in the darkness as far as his light carried him. All beyond that was chance to each; and fate willed that Newton, whose light shone farther than his rival's, found it extended just far enough to show the entrance to the wrong way. He reaches the conclusion that we all know; one not only wrong in regard to light but which bears pernicious results on the whole theory of heat, since light, being conceded to be material, radiant heat, if affiliated to light, must be regarded as material too; and Newton's influence is so permanent, that we shall see this strange conclusion drawn by the contemporaries of Herschel from his experiments made a hundred years later. It would seem then that the result of this unhappy corpuscular theory was more far-reaching than we commonly suppose.[3]

This comment of Langley's was written about forty years ago, at a time when the wave theory was quite universally accepted. Now it is thought by many that Newton in adopting the corpuscular theory of light denied the existence of the ether. But this is far from the truth, as his own writings unmistakably show. To illustrate, in offering an explanation under the corpuscular theory of the fact that a transparent body, a sheet of glass for example, can at the same time reflect and refract, he considers that the corpuscles are subject to "fits of easy reflection and easy transmission" communicated to these particles by undulations in an all-pervading ether. The ether at the surface of the body, agitated by the flying particles, is alternately compressed and rarefied, and a particle at the surface in a compression is thrown back, whereas in a rarefaction it passes through. Other references, particularly in the "Queries," are equally illuminating. The significant fact just here is that even Newton, the most distinguished opponent of the wave theory of light, found it necessary in his thinking to employ the ether concept.

It came about then, that notwithstanding the very able defense of the undulatory theory by Hooke, Huygens and others, and largely because of Newton's overpowering authority, the corpuscular hypothesis rose in power and for a long time remained in the ascendancy. Cajori states that "the only prominent writers of the eighteenth century who advocated the undulatory theory were Leonard Euler and Benjamin Franklin."[4]

At the beginning of the nineteenth century (1801), Thomas Young after a study of the colors of thin plates, the familiar soap-bubble colors, declared himself in favor of the wave theory for the following reasons. These colors are explained under other theories only with greatest difficulty and by the aid of most gratuitous assumptions, whereas "the minutest particulars of these phenomena are not only perfectly consistent with the [wave] theory . . . but . . . they are all the necessary consequences of that theory, without any auxiliary suppositions."[5]

Some years later (1815) Fresnel became strongly convinced of the truth of the wave theory, and deeply impressed by its power to explain transmission, he succeeded in accounting for rectilinear propagation on the wave theory basis, and also explained more fully two other troublesome matters, namely, diffraction and interference. As a result of the work of Young and Fresnel, there once more arose a bitter contest between the advocates of the opposing theories of light.

Just at the middle of the century (1850) came the experiments of Fizeau and Foucault and their so-called laboratory methods for measuring the velocity of light. These methods made it possible to put to the test the old controversy as to whether light travels faster or slower in a denser medium. The corpuscular theory demanded a faster, the wave theory a slower speed in the denser medium. The test was now made and showed that the velocity of light in water was only about three fourths that in air. This was strong evidence for the wave theory.

Foucault's experiment was by many regarded as a crucial test, and as a result the ether wave theory came into greater prominence and was, in fact, quite generally accepted.

In the meantime (about 1835) Faraday's researches, in a field apparently unrelated to light, had pointed to a need for a medium to explain electrostatic and magnetic effects. And a few years later (1863) in the process of developing a mathematical statement of Faraday's results Maxwell reached the conclusion that in such a medium as Faraday postulated it ought to be possible to establish electromagnetic waves. Furthermore, as soon as a numerical relationship could be established experimentally between electrostatic and magnetic units of measurement, the velocity of such waves was calculated and proved to be the same as that of light. This was an astounding discovery which excited the interest and admiration of the world.

Now it can easily be seen that if a luminiferous ether was necessary to account for the transmission of light, and an electromagnetic ether was needed in electrical theory, and if, furthermore, the velocity of

[3] F. Cajori, "A History of Physics," revised, p. 109.
[4] *Loc. cit.*, p. 110.
[5] "Classics of Science," *Science News Letter*, November 2, 1929, p. 273.

propagation of a disturbance proved to be the same in each the question would naturally arise whether the same medium might not answer both requirements. Maxwell concluded that light is an electromagnetic phenomenon and that light waves are in fact electromagnetic waves like those he had been studying, differing only in wave-length. This formulation of Maxwell's electromagnetic theory of light was regarded as one of the most brilliant generalizations in the history of science.

The production of long electromagnetic waves such as were first contemplated by Maxwell offered no appreciable difficulty, since suitable apparatus was available in almost any physics laboratory. But a detector or receiver for such waves by means of which their existence could be proved or demonstrated was a different matter. No one knew how to construct such a device, and as a consequence, verification of Maxwell's theory by experiment was for a time delayed.

Some years later (1888) Hertz succeeded in devising a receiver. As soon as he had done this he proceeded to a detailed study of the electromagnetic waves produced by his laboratory apparatus and verified the predictions of Maxwell's theory, showing that these waves were similar to light waves in many of their properties and were propagated with the same speed.

Supported by the results of Hertz's experiments, Maxwell's theory became firmly entrenched and the position of the ether concept, now greatly strengthened, seemed well-nigh impregnable.

Our discussion has now brought us near but not quite to the close of the nineteenth century. In those few remaining years discoveries were to be made which would have far-reaching effects on all branches of science. In 1895 Roentgen discovered the X-rays, and shortly thereafter came the announcement of radioactivity and the identification of the electron as one of the building-stones common to the atomic structures of all the elements.

These discoveries aroused the interest of the entire world and greatly stimulated scientific research in many fields. Their importance, so far as concerns our discussion, lies in the fact that they directed the attention of the scientific world to a closer study of the general subject of radiation.

The ether theory gave scant information as to the mechanism of the radiation process. It was a theory of transmission. It gave a good account of how the energy of light and radiant heat is carried through empty spaces and accounted for many of the phenomena characterizing transmission, but it did not explain the mechanism by means of which such energy is started on its way, and its explanation of the effects which accompany the absorption of this wave energy was hazy and at times wholly inadequate.

It now developed that certain phenomena of radiation and absorption could be explained on a satisfactory basis only on the assumption that radiation is a discontinuous process, that radiant energy is broken up into parts or parcels. And lo! there arose before the scientific world the specter of the corpuscular theory, the body of which had long since been laid away.

This time (1901) the theory was given the name of the quantum hypothesis, and it treated not of corpuscles but of quanta. It was a new theory, to be sure, but one which as it developed was to show a most striking resemblance to the corpuscular theory of a time more than two centuries past.

Now the X-rays were later found to be identical in character with light waves except as to wave-length. So also for the gamma rays, one of the radiations from radioactive bodies. These new forms of radiation fitted nicely into the ether wave series occupying regions in the wave scale hitherto vacant and unexplored. So also the new theory of atomic structures which gave a picture of the atom as consisting principally of wide open spaces really strengthened the ether theory by removing one of its great obstacles. It had been objected that the interpenetration of ether and matter was difficult to conceive, and so under the old theory of solid, closely packed atoms it was; but under the new theory of an open atomic structure this difficulty largely disappeared. These new discoveries, then, did but little if anything to impede the triumphant progress of the ether wave theory.

But the quantum theory, giving a more plausible explanation of radiation and absorption, constituted a real menace. I shall leave this consideration for the present, however, as we must now turn our attention to a different phase of the general question.

It was pointed out long ago that if this ether medium actually exists there ought to be an ether drift past the earth caused by the motion of the earth along its orbit. The effect here contemplated is analogous to the air drift one feels when traveling rapidly, in an open car for instance, through still air. Now if the earth moves through the ether without disturbing it there must be an ether drift, and light should be found to travel faster when moving with the ether than when it moves against, or across, the ether stream.

A little more than forty years ago (1887) an attempt was made by Michelson and Morley to detect or measure this effect. Elaborate preparations were made for this experiment and it was carried out with

the greatest possible care. The experiment gave negative results and this was generally accepted as proving the absence of an ether drift. "The earth seemed to drag the ether with it."

Now it must be allowed that the negative result of the Michelson-Morley experiment is to be interpreted in one of three ways. The first of these possible interpretations is that there is no ether. The second is that there is an ether but no drift because the ether is dragged along with the earth. The third interpretation is that there is an ether and also an ether drift, but for some reason the drift was not detected in the experiment.

It is significant as showing the firm hold which the ether theory had on the minds of men that few, if any, accepted the results of this experiment as proving the non-existence of the ether and practically all explanations offered were based upon the second or third interpretation.

Sir Oliver Lodge attempted to demonstrate an ether drag between two massive steel plates revolving at enormous speeds, but was unsuccessful. Had this experiment succeeded, an explanation might have been possible under the second interpretation.

FitzGerald and others directed attention to the third interpretation and suggested inherent defects in the method, the apparatus or perhaps in both. A suggestion offered by FitzGerald was of far-reaching importance. He pointed out that if, as modern theory would indicate, matter is electrical in its nature, it may contract in the direction of motion as it moves through the electromagnetic ether. Such contraction, he explained, would under ordinary circumstances quite escape attention since any scale used to measure it would also be subject to the same effect, so that, in the direction of motion, the unit of length would be shortened.

Thus the various parts of the Michelson-Morley apparatus, although not showing it in any other way, might change in length, as they were placed alternately parallel and perpendicular to the direction of motion, to such an extent as to compensate for the effect it was expected the test might show. This suggested explanation, known as the FitzGerald contraction, was at first not altogether well received, no doubt largely because of its very novelty.

The justly famous Michelson-Morley experiment, it would seem, has thus far yielded results of doubtful significance. It has been repeated a number of times by Morley and Miller and by Miller and others in different localities, at different altitudes, with more elaborate equipment and under better conditions as to temperature control, always with results more or less open to question. However, it should here be recorded that Miller, in his report to the National Academy of Science last year, stated that he believes he has measured an ether drift, although he is not yet ready to pronounce it an established fact.

Just after the opening of the present century (1905) the scientific world was set to thinking about these and related matters in a new way. This was occasioned by the announcement of Einstein's special theory of relativity. This theory teaches that when such changes as the FitzGerald contraction take place in our standards we must, in the very nature of things, be totally unaware of them, since we move with them and suffer like changes ourselves, but they might be measurable to an observer having different motion. It follows logically that time and space are therefore not absolute concepts but are relative only, in any given case, to the observer.

Under this theory the negative results of the Michelson-Morley experiment are exactly what one would expect. Indeed, one of the two great postulates upon which this theory is founded states that the velocity of light is always the same whatever the apparatus used in its determination, whatever the circumstances under which the measurement is made.

It is sometimes asserted that Einstein's theory is founded upon the negative results of the Michelson-Morley experiment and that it denies the existence of the ether. These statements are only partially true and perhaps should not be regarded as serious objections to the relativity theory. It seems probable that if, perchance, the ether drift is at last demonstrated to be a fact, this or an equivalent theory will be reconstructed on a similar, or possibly quite different, basis, for the results which have come from the theory of relativity seem of themselves a sufficient justification of the theory.

As regards the other assertion, it may be pointed out that Einstein concedes that the ether concept can not at present be dispensed with even in this strange world which he has builded on the foundation of relativity.

Our attention turns now to a consideration of some of the more recent developments in the new physics. The quarter of a century which has elapsed since the advent of Einstein's special theory will long be celebrated in the story of scientific progress for the revolutionary changes which it has witnessed in the theories and methods of physical science. It is probably not too much to say that never in the history of man's intellectual advance has there been a similar period so filled with changing theory! These new theories have to do largely with the structure of matter and the nature of radiation, and to them all the subject of the ether concept is related in an important way.

It might easily be imagined that as the quantum

theory advanced step by step, becoming apparently ever more firmly established, the ether wave theory must have become of lesser and lesser importance. But evidently such has not proved to be the case.

The quantum theory grew in power as it helped to solve the problems of emission and absorption, but it was unsatisfactory in explaining the phenomena of transmission. On the other hand, the wave theory gave a good account of transmission, and as a consequence being firmly entrenched in this field, was able in a large measure to withstand the onslaughts of the quantum hypothesis.

It will not be out of place to mention here one or two points of advantage possessed by the wave theory. The quantum theory does not give a satisfactory answer to the question: Why do all quanta, large and small, travel through empty space with the same velocity? It is understood that quanta vary greatly in size. The constant of this theory is a factor, h, which multiplied by the associated frequency in a given case gives the quantum energy. Hence the quantum of high frequency radiation is relatively large, while that of low frequency radiation is small.

It does seem strange that two radiators, the one hot and the other cold, throwing off, therefore, quanta of different size, should shoot them out into space with exactly equal velocities. Now there is nothing strange about equal velocities of waves in the ether. Ether wave velocities depend upon the ratio of what we may call the elasticity and mass properties, actually the electric and magnetic properties, of the ether, and upon these alone. Such velocities are therefore always the same regardless of wave-length. We have a somewhat analogous case in the passage of sound waves through the air. Under ordinary conditions, at least, long and short sound waves travel with the same speed.

In other cases the advantages of the wave theory are not so apparent. For example, the quantum theory gives no answer to the question: How large is a quantum? The wave theory, of course, is not called upon to answer this specific question, but is required to answer a closely related one which is almost equally difficult, as we shall see.

An examination of the star image formed by a one-hundred-inch reflecting telescope indicates that the quantum must reach all parts of the mirror. This means that a quantum must be large enough to cover a mirror more than eight feet in diameter. But if light from this same star falls directly upon a potassium film it will eject electrons. This means a quantum must be small enough to enter an atom. It is very difficult to reconcile these results.

Now if we try to explain such effects from the standpoint of the wave theory we also get into trouble. There is, of course, no difficulty in covering a one-hundred-inch mirror with an ether wave front but when we come to the effect upon the potassium film the matter is not so simple. Each electron thrown off from the film escapes with a definite speed and carries away a definite energy, the amount of which has been shown to depend upon the incident light alone. It varies with the wave-length of the incident light but is independent of its intensity. It is the same for feeble light as for strong.

This curious but apparently well-established fact that light of low intensity ejects electrons from the potassium film with the same velocity as that produced by light of the same quality but much higher intensity is called the "photoelectric paradox." The electrons ejected under high intensity radiation are more numerous but they travel with no greater speed.

To illustrate, when light from the star Sirius, fifty billion miles away, falls upon the potassium film, the electrons are actually ejected with greater speed or energy than they are when stimulated by exposure to the light from the sun. This effect does seem altogether paradoxical, since the sun's light is enormously more intense and, as already stated, the energy of the ejected electrons comes from the stimulating radiation. But the energy of the electron emitted does not depend upon the intensity of this radiation. It is determined by the frequency alone. Now Sirius is a bluer, that is, a hotter, star than the sun. Thus it comes about that notwithstanding its low intensity the light from the star, because of its higher frequency, can throw out electrons from potassium at the higher speed.

But how are these effects to be explained on the basis of the wave theory? Consider the spread, the extreme attenuation of the energy of this spherical wave front having a radius of fifty billion miles. How can it carry still, in a microscopic portion of its wave front, the energy requisite to this atomic explosion?

There are then certain phenomena well accounted for by the quantum hypothesis, others which are more readily explained by the wave theory and certain others which are not very well described by either.

This state of affairs has enabled the wave theory, in spite of its shortcomings, largely to hold its own in the face of the rising popularity of the quantum hypothesis. And so it has come about that with the passing years both these rival theories have continued in use.

In his fascinating book, "The Nature of the Physical World," published about a year ago, Eddington reminds us that "for at least fifteen years we have used classical laws and quantum laws alongside one another notwithstanding the irreconcilability of their

conceptions."[6] And farther on by way of illustration he says:

> In my observatory there is a telescope which condenses the light of a star on a film of sodium in a photoelectric cell. I rely on the classical theory to conduct the light through the lens and focus it in the cell; then I switch on to the quantum theory to make the light fetch out electrons from the sodium film to be collected in an electrometer. If I happen to transpose the two theories, the quantum theory convinces me that the light will never get concentrated in the cell and the classical theory shows that it is powerless to extract the electrons if it does get in. I have no logical reason for not using the theories this way round; only experience teaches me that I must not.

He goes on to quote the famous saying of Sir William Bragg that "we use the classical theory on Mondays, Wednesdays and Fridays, and the quantum theory on Tuesdays, Thursdays and Saturdays," and then remarks, "Perhaps that ought to make us feel a little sympathetic towards the man whose philosophy of the universe takes one form on week-days and another form on Sunday."

It is the conviction of many, if not all, physicists that a rearrangement of our ideas of the physical world will come which will reconcile these two great theories. Some apparently believe it will come through a further development of the classical theory; others that it will come from the other side.

We turn now to a consideration of the ether concept in relation to the modern theories of atomic structure.

The atom, according to Bohr's theory, consists of a central nucleus of large mass and positive charge about which minute negative electrons revolve like satellites in a miniature solar system. These electrons are restricted to certain special orbits and the atom can neither radiate nor absorb energy while the electrons continue their orbital motions unchanged. According to Bohr, radiation or absorption is possible only when electrons jump from one orbit or "energy level" to another. The assumptions upon which this theoretical structure is based are founded upon a strange mixture of the classical theory, the quantum hypothesis and the general theory of relativity.

This picture of the atom was for a time remarkably successful, particularly in explaining such facts as the curious grouping of lines in the spectra of the elements. However, there are certain other matters, such as line intensities and particular line groupings, which it explained in a way not altogether satisfactory, if at all. It was recognized some time ago that this theory would have to be modified if not altogether replaced by a new theory of atomic structure.

[6] A. S. Eddington, "The Nature of the Physical World," p. 194.

A number of physicists have been active in this field of investigation. Outstanding among these are de Broglie, Heisenberg, Dirac and Schroedinger. In the past few years the theories proposed by these men have been repeatedly revised and extended until at the present time we have an entirely new picture of the atom.

Under the new theory of "wave mechanics" which has resulted, the electrons within the atom are believed to be accompanied by groups of waves, the extreme assumption being that an electron consists entirely of waves, that the wave group is, in fact, the electron. This is a theory which is apparently quite as good as Bohr's theory in its own field and appears to be capable of much greater extension.

A few years ago A. H. Compton discovered experimentally an effect which seemed to indicate that waves sometimes behave like particles, and Davisson and Germer proved that electrons reflected from a crystal of nickel are grouped in a manner to indicate that small particles in rapid motion behave somewhat like waves.

Also G. P. Thomson by passing a stream of cathode rays or swiftly moving electrons through a very thin metal film found that the metal scattered the electrons, the distribution of the scattered electrons being exactly that which would occur in the diffraction of waves like X-rays by the known crystal structure of the metal film.

Now it had been suggested by de Broglie that the reason the electron in the atom behaves in such a peculiar manner, seemingly following at one time the classical laws and at another the rules of the quantum theory, was that its real nature was more like that of a wave than a particle. It is easy to understand that the results of the experiments just described are in accord with de Broglie's hypothesis.

We must now consider how the phenomena just recounted are related to the ether hypothesis and determine what rôle the ether plays in the new wave mechanics.

You will understand that waves and wave groups are conspicuous features of this new theory. But waves in what?

It must strike the student of wave mechanics rather forcibly that while the discussion of these waves and their properties is quite free from hesitation and embarrassment any mention of the wave medium is made apparently with great reluctance and where possible is avoided altogether. Now a wave is a disturbance of the equilibrium of a medium. Without a medium there can be no waves, and to postulate waves is to postulate a medium in which such waves are formed and propagated.

The real explanation of this strange situation is

found not in any disinclination on the part of the modern physicist to make use of the ether concept, which has been so freely employed in earlier science, but rather in the failure on the part of the ether to qualify in this particular field. For the medium required by the wave mechanics is a dispersive medium, that is, one in which waves of different length have different velocities. It is a necessary requirement that the shorter waves shall travel faster than the longer ones. Now in the ether all waves travel with the same speed. The ether, therefore, is unable to meet the requirements of this new theory.

For the first time, says G. P. Thomson, physics is faced with waves in empty space which do not fit into the ordinary series of ether vibrations.[7] These electron waves are of about the size of those in the X-ray spectrum, but of course they can not be X-ray waves, since these belong to the ether series and have the properties of ether waves.

To meet this difficulty the bold suggestion is made that we postulate an entirely new medium having the desired characteristics. Enters now the concept of the *subether*. Concerning this assumption Thomson says, "It is not a very attractive idea to have two ethers filling space, especially as the waves of protons, if they exist, would demand yet a third. Space is getting overcrowded."[8]

It is significant that the subether is proposed as an additional medium and not as a substitute for the ether of earlier theory. This can be interpreted only as meaning that regardless of the need for a dispersive medium we can not dispense with the luminiferous ether; that this medium is still necessary in our thinking to account for the propagation of all those forms of radiation heretofore classified as ether waves.

The universe is made up largely of open spaces. The stars and the island universes we see in the night sky are at almost inconceivable distances from the earth, and they are separated from each other by spaces equally great. Ordinary matter is constructed on the same plan. It is extremely porous. This is a fact which ordinarily escapes our attention; but if it were possible sufficiently to magnify its structure, modern theory teaches that so magnified its appearance would be much like that of the sky at night. We should see a multitude of material specks separated by great distances like those between the stars.

Across these spaces these specks of matter, stars and atoms, act upon each other. They are bound together by gravitation, by electrostatic and magnetic forces and by cohesion, and between them various forms of energy are incessantly streaming to and fro. Do these forces and energy streams extend through empty space? Or is there a medium for their transmission?

It may be difficult to conceive of a non-material, all-pervading medium which serves as a carrier of these forces; but it is even more difficult to imagine these interactions in a space which is absolutely void.

Newton said:

> That one body may act upon another at a distance, through a vacuum, without the mediation of anything else by and through which their action may be conveyed from one to another, is to me so great an absurdity that I believe no man, who has in philosophical matters a competent faculty for thinking, can ever fall into it.[9]

Sir Oliver Lodge says:

> Always look for the medium of communication: it may be an invisible thread, as in a conjuring trick; it may be the atmosphere, as when you whistle for a dog; it may be the ether, as when you beckon to a friend.[10]

Says Einstein:

> To deny the ether is ultimately to assume that empty space has no physical properties whatever. The fundamental facts of mechanics do not harmonize with this view . . . According to the general theory of relativity space without ether is unthinkable, for in such space there not only would be no propagation of light, but also no possibility of existence for standards of space and time.[11]

And finally, as regards the importance of the ether concept in modern physics we shall probably be inclined to agree with Eddington who expresses his views in the following words.

> We need an ether. The physical world is not to be analyzed into isolated particles of matter or electricity with featureless interspace. We have to attribute as much character to the interspace as to the particles, and in present-day physics quite an army of symbols is required to describe what is going on in the interspace. We postulate ether to bear the characters of the interspace as we postulate matter or electricity to bear the characters of the particles. . . . The ether itself is as much to the fore as ever it was, in our present scheme of the world.[12]

[7] SCIENCE, December 6, 1929, p. 545.
[8] *Ibid.*

[9] Quoted by Lodge, "Ether and Relativity," p. 79.
[10] *Loc. cit.*, p. 80.
[11] "Sidelights on Relativity," quoted by Lodge in "Ether and Reality," p. 123.
[12] A. S. Eddington, "Nature of the Physical World," pp. 31–32.

OBITUARY

HARVEY WASHINGTON WILEY

DR. WILEY was born in Kent, Jefferson County, Indiana, on October 18, 1844. His broad education was achieved in spite of the almost complete absence of early opportunities. Public schools were unknown there in his early life. In his rural community schools were supported by subscription, when available at all, and were limited to about three months during the winter season.

Until 1862, when he was eighteen years of age, his schooling consisted of four of these winter sessions. During that year he entered the preparatory department of Hanover College. During his sophomore year in college, in May, 1864, he enlisted in the Union Army and served until the end of the war. He graduated from Hanover in 1867, having given his chief attention to Latin and Greek, although it was his aim to study medicine.

In 1868, he was appointed instructor of Latin and Greek in the Northwestern Christian University, now Butler University, at Indianapolis. While occupying that position he studied at the Indiana Medical College and received the degree of doctor of medicine in 1871. The following year he was appointed professor of chemistry of the Indiana Medical College and given a year's leave of absence at his request for advanced study. This year was spent at Harvard College, where he was given the degree of bachelor of science in 1873.

In 1874, Purdue University was organized and Dr. Wiley was appointed professor of chemistry, which position he held until appointed chief chemist of the U. S. Department of Agriculture in the spring of 1883. During this period he spent a year in Europe where he had the opportunity to work with Dr. Sell, the director of the Imperial Health Laboratory at Berlin. Here he became familiar with the work of that laboratory on food analysis and particularly on the examination of sugars and syrups. On returning to Purdue he secured a small appropriation from the state legislature, which made possible a systematic examination of the sugars and syrups then on sale in Indiana. He also had some practical experience at that time in the manufacture of sorghum syrup and sugar.

The most noteworthy achievement of the first ten years of Dr. Wiley's service as chief chemist of the Department of Agriculture was probably the series of contributions made by him and his associates to the manufacture of sugar. Largely owing to his efforts, strains of beets were developed with a higher sugar content than was formerly known. Exhaustion batteries used in the manufacture of beet sugar were introduced into the cane sugar industry and led directly to the improvement of the presses of that industry to a much higher degree of efficiency. During this same period epoch-making contributions were made under Dr. Wiley's direction to the chemistry of soils and of cereals.

During the same period much attention was also given to the subject of food analysis, especially for the purpose of detecting adulterations. As a result of this work, Bulletin 13 was published, consisting of ten parts. The first part, on dairy products, was published in 1887, and the tenth part, on preserved meats, in 1902. This series of bulletins, giving the methods of analysis developed for the various products studied and the results obtained by those methods from foods purchased in the markets, afforded the best literature of that time on the subjects of food analysis and food adulteration.

During his first year as chief chemist of the Department of Agriculture, Dr. Wiley was elected president of the Association of Official Agricultural Chemists at its third annual meeting and was more active than any other member of the association while he remained in official life. At the sixth annual meeting of the Association of Official Agricultural Chemists, he was elected secretary, which position he held until he resigned from the department in 1912. He was then made honorary president of the association and addressed each meeting until the year 1929, when illness prevented him from attending the meeting.

His studies on food adulteration impressed on him the need of federal legislation which would control the purity of foods and drugs. He wrote many articles and gave many addresses on this subject. The first pure food bill was introduced in Congress in 1889. Various bills were introduced after that time, but manufacturing interests succeeded in preventing their passage for a period of seventeen years. Finally in 1906, the Food and Drugs Act, written by Dr. Wiley, was passed by Congress and signed by the President. Its passage and perhaps its approval by the President were the results of a tremendous popular demand which was due undoubtedly to the personal influence of Dr. Wiley.

His life was militant and, perhaps, spectacular. He had many enemies as a result of his intense activity in behalf of legislation for the public good. Largely because of the same activity, his friends were beyond number. Intensely partisan, he retained the respect and admiration of the most bitter opponents of his policies. Although the center of a series of storms during his long and active life, his buoyant

wit and humor averted many a threatened clash and won many victories.

He had the faculty of applying his fertile mind intensely and worked rapidly. When a period of work was over he was able to dismiss it entirely from his mind. He was an ardent baseball fan and, in fact, was interested in sports of all kinds. His kindly interest in their welfare endeared him to his associates. A keen student of human nature, he was a prince of good fellows. He loved a good story, and always told a better one. He was a patron of literary and musical events of his community.

He owned the third automobile in Washington and always claimed to have met with the first accident, in which he encountered the first "hit-and-run" driver, who, however, drove a team of horses and not an automobile. His experience at Purdue University led him into several embarrassing situations because of his tendency to vary from accepted traditions. During that period, for instance, charges were preferred against him for donning a uniform and playing baseball with the boys and also for riding a bicycle while wearing knee breeches.

His activities were not, by any means, limited to his duties as chief chemist of the Department of Agriculture. Before and after his resignation from that department he published a series of books, which alone were sufficient for a man's life work. He was elected president of the American Chemical Society in 1893 when it numbered some four hundred members. He remained president for two years, when largely because of his activities the membership of the society had increased to over a thousand. During this period he presided at the World's Chemical Congress which met at the Chicago Exposition in 1893.

After his resignation from the Department of Agriculture in 1912, he wrote a chapter for each issue of *Good Housekeeping* and conducted a correspondence bureau for that magazine until January 1 of the present year. During the first seven years after his resignation from the department he also lectured in Chautauqua circles. Then, because of failing eyesight and defective hearing, he gave up regular lecturing.

In 1921 the cataracts which were forming in his eyes reached the stage which required operation. For a time he was unable to read; always after that he read with difficulty. His hearing had become impaired. These limitations lessened his diversions but increased the constancy and earnestness of his work. He continued to publish books, to write his regular chapter for *Good Housekeeping* and to conduct an extensive correspondence bureau. He continued to participate in public hearings relating to a wide range of popular interests. Within a month before his death he participated in two public hearings relating to the enforcement of the Food and Drugs Act.

To the public Dr. Wiley was best known as the "father of the pure food law." Those who knew more intimately the position he achieved in the field of science, both at home and abroad, the breadth of his vision, the courage of his character and the scope of his interest in all questions relating to the public welfare recognized in him a leader among leaders—a man whose death on the thirtieth of June was an international loss.

W. D. Bigelow

SCIENTIFIC EVENTS

THE SIXTEENTH INTERNATIONAL GEOLOGICAL CONGRESS

Representatives of the principal geological groups in the United States have selected a committee on organization for the next meeting of the International Geological Congress which will be held in the United States in 1932. The officers of the committee so far chosen are: Honorary president, Herbert Hoover, President of the United States; chairman of the committee, Professor Waldemar Lindgren, Massachusetts Institute of Technology; general treasurer, Professor Edward B. Mathews, the Johns Hopkins University; general secretary, W. C. Mendenhall, U. S. Geological Survey; assistant secretaries, H. G. Ferguson and M. I. Goldman, U. S. Geological Survey. The members of the committee are as follows.

L. K. Armstrong, Spokane, Washington; Dr. H. Foster Bain, American Institute of Mining and Metallurgical Engineers; Professor A. M. Bateman, Yale University; Dr. C. P. Berkey, Columbia University; Dr. Eliot Blackwelder, Stanford University; Dr. Isaiah Bowman, American Geographical Society; H. A. Buehler, State Geological Survey, Missouri; Professor R. A. Daly, Harvard University; Dr. A. L. Day, Geophysical Laboratory, Carnegie Institution; E. DeGolyer, New York City; C. A. Fisher, Denver, Colorado; H. G. Ferguson, U. S. Geological Survey; M. I. Goldman, U. S. Geological Survey; President W. O. Hotchkiss, Michigan College of Mining and Technology; Arthur Keith, National Research Council; Dr. H. B. Kummel, State Geological Survey, New Jersey; Professor H. Landes, University of Washington; Professor A. C. Lawson, University of California; Dr. C. K. Leith, University of Wisconsin; Professor Waldemar Lindgren, Massachusetts Institute of Technology; Professor E. B. Mathews, the Johns Hopkins University; W. C. Mendenhall, U. S. Geological Survey; Professor R. A. F. Penrose, Jr., Philadelphia; Dr. Sidney Powers, Amerada Petroleum Corporation, Oklahoma; W. E. Pratt, Humble Oil and Refining Com-

pany; Dr. George Otis Smith, U. S. Geological Survey; Scott Turner, U. S. Bureau of Mines; W. E. Wrather, Dallas, Texas; David White, U. S. Geological Survey.

The committee on organization has appointed the following officers and members as an executive committee: Professor Waldemar Lindgren, Professor Edward B. Mathews, W. C. Mendenhall, Dr. H. Foster Bain, Dr. C. P. Berkey, E. DeGolyer and David White.

The general sessions of the congress will be held early in June, 1932, in Washington, D. C., the precise date to be announced later. They will be preceded late in May, and followed in June and early in July, by a series of excursions.

The conditions of membership in the congress are here outlined: "No professional title is required to register. Nevertheless, the excursions organized before and after the sessions will be more especially reserved for the members of the congress who are geologists, geographers and mining engineers and for other persons who devote themselves to the study or practice of some branch of geology."

Following the admirable practice of recent congresses, each of which has prepared a special volume on the world reserves of some mineral resource that is particularly well represented in the country in which the congress is held, the organization committee of the sixteenth congress is planning the preparation and publication of a monograph on the petroleum resources of the world. It is expected that selected papers on the geology of petroleum will have conspicuous places on the program of the sessions. The following topics of current interest to geologists are also proposed for consideration by those who plan to attend the congress:

1. Estimates of geologic time by method.
2. Batholiths and related intrusives.
3. Origin of lead and zinc deposits like those of the Mississippi Valley and Silesia.
4. Zonal relations of metalliferous deposits.
5. Evidence of cycles in sedimentations, including valves.
6. Major divisions of the Paleozoic system.
7. Boundaries of the Tertiary system and its major divisions.
8. Adaptation of extinct animals and plants to their environment as indicated by fossils.
9. Physiographic processes in arid regions and their resulting forms and products.
10. Fossil man.

Offers of papers or comments on these topics or suggestions as to other desirable topics are invited and should be submitted to the general secretary as soon as possible.

Excursions are planned for members of the congress to various points of interest in the United States. Inquiries or proposals relating to the work of the sessions or to the future activities of the committee should be addressed to the organization committee through the general secretary, Sixteenth International Geological Congress, Washington, D. C. Circulars to be issued later will present additional details and will record progress in the development of plans for the congress.

HARVARD FOREST FUND

THE oldest forest experiment station in the country, the Harvard Forest at Petersham, Massachusetts, will now be able to carry on its forestry study with greater facility, according to an announcement made recently by the director, Professor Richard T. Fisher, instructor in the Bussey Institution of Harvard University, who said that the endowment of $200,000 for research work has now been completed.

Charles Lathrop Pack, of Lakewood, N. J., noted financier and one of the fathers of the forest conservation movement, started the endowment, which is known as the Charles Lathrop Pack Forestry Trust, with a gift of $100,000. It was stipulated in the donation that a similar amount should be obtained from other donors.

Of two gifts by Mr. Pack during the past two years, one was to Yale University, a tract of forest land located near Keene, N. H., adjacent to the forest land already owned by Yale University; the other, a gift of $200,000 to the University of Michigan to establish a foundation for the promotion of practical forestry management.

Mr. Pack is president of the American Tree Association of Washington, D. C. More than any other individual, he has succeeded in putting the importance of reforestation before the public in a way which has made it known to thousands. Through his efforts millions of American tree seeds have been sent to Europe to help in reforesting devastated areas.

The Harvard Forest, which is connected with the Bussey Institution, offers boundless facilities for the studies of forest entomology, forest management and silviculture. Among other accomplishments it has shown how new timber can be grown profitably on land which has once been cut over.

Harvard University first acquired land in Petersham in 1907 when a gift of about 2,000 acres of valuable timberland, about five miles from Athol on the Athol-Petersham road, was made possible through the generosity of John S. Ames, of Boston. Several neighboring tracts were later added.

WOMAN'S COLLEGE AT DUKE UNIVERSITY

WE learn from the Baltimore *Sun* of the opening of the Woman's College of Duke University, one of the new divisions of the institution, on September 24.

With the freshman class of the college restricted to 250 students, women students will have a well-equipped plant of their own for the first time.

Included in the buildings on the Woman's College campus is the group of eleven buildings completed in 1927 at a cost of approximately $4,000,000 and erected especially for the uses of women. Since that time, however, these buildings have been occupied by men pending the completion of the university's larger plant on an adjoining campus.

While students of the Woman's College will have full physical equipment and academic facilities of their own, they will be permitted to take courses on the main university campus if they desire to do so. Included also in the new Woman's College plant is the large gymnasium built several years ago as a memorial to Trinity College alumni who died during the World War. This unit will permit a full program of intramural sports among the women students. There are nineteen buildings in the Woman's College group, situated on a 110-acre campus.

In addition to members of the university faculty who will teach in the Woman's College, additional teachers have been added to the staff to give the Woman's College ample instructional services. Dr. Alice M. Baldwin, who has been dean of women at Duke University for several years, is dean of the Woman's College.

Degrees were conferred upon women by Trinity College as early as 1878, but the real history of education of women at the college did not begin until 1896.

MINING AND METALLURGICAL ADVISORY BOARDS

THE fourth annual meeting of the Metallurgical Advisory Board to the U. S. Bureau of Mines and the Carnegie Institute of Technology, which will take place on October 17, at Pittsburgh, Pa., will open in the auditorium of the Bureau of Mines with an address of welcome by Dr. F. N. Speller, chairman of the advisory board and director of the department of metallurgy and research of the National Tube Company. Following this, metallurgists of the bureau of metallurgical research, Carnegie Institute of Technology, will give a progress report on iron-manganese-carbon alloys, a study which has been conducted by them for several years. Dr. F. M. Walters, Jr., director of the bureau, Dr. V. N. Krivobok, Dr. J. B. Friauf, Mr. Cyril Wells and Mr. Maxwell Gensamer, associates, will present papers on different phases of this study. Dr. Krivobok will also report on his studies on the stainless iron alloy.

During the afternoon session Dr. C. H. Herty, Jr., physical chemist of the U. S. Bureau of Mines, and Dr. G. R. Fitterer, associate metallurgist, will present an illustrated report on slag viscosity and deoxidation with aluminum-silicon alloys, and a progress report on fundamental studies in the laboratory. Dr. Herty will also deliver a report on plant research in open-hearth steel. The several reports will be interspersed with discussions by prominent metallurgists from all parts of the country relative to steel problems.

The meeting which will be held in the evening at the Pittsburgh Athletic Club will be followed by an informal dinner at which Dr. Thomas S. Baker, president of the Carnegie Institute of Technology, will preside.

THE INTERNATIONAL INSTITUTE OF AGRICULTURE

THE New York *Times* reports that the international Institute of Agriculture, founded in Rome by a distinguished Californian, David Lubin, is about to celebrate its twenty-fifth anniversary. From its humble origins twenty-five years ago when its foundation was possible only through the munificence of the King of Italy, it has now become one of the most important of international organizations and counts seventy-four states among its members. It has fulfilled the dream of its founder, becoming a kind of agricultural League of Nations, but David Lubin is no longer alive to see the triumph of the child of his genius.

For the celebration of the twenty-fifth anniversary the greatest meeting of ministers of agriculture that ever occurred will be held in Rome. Ministers of agriculture of all seventy-four member states have been invited and it is believed almost all will attend. The King of Italy will be present as patron of the institute and the meeting will address to him expressions of gratitude for the rôle he played twenty-five years ago.

It is expected also that advantage will be taken of the presence of such a large number of ministers of agriculture to discuss numerous subjects affecting the future of the institute and increasing its usefulness to humanity.

The real celebration of the anniversary, however, will take the form of bringing to completion the work of a complete census of agricultural activities of the whole world which was begun five years ago.

Two hundred governments—almost all the governments in the world—contribute to this census. Questionnaires were submitted to the governments by the institute, which also assumed the task of classification of the replies. This is said to be an improvement on the system followed hitherto, because the various governments which have been publishing information about their agriculture have done so in such different manners that comparison between one nation and another was extremely difficult.

Of the two hundred governments, only about sixty

hitherto have taken censuses of agriculture and very few of these refer to the same year. Annual statistics of principal agricultural products published by most of them are simple approximations of estimates which can be relied on only slightly.

The institute in 1925 established an office in Rome headed by specialists. Its first task was to formulate a program for the world census and then to prepare the questionnaires in all languages of the world, with clear indications for answering them to insure uniformity. Final figures on the census have begun reaching Rome. It is hoped that before the end of the year the material will be complete, permitting publication of the census.

SCIENTIFIC NOTES AND NEWS

PROFESSOR ALBERT PERRY BRIGHAM, professor of geology at Colgate University since 1892 and consultant of geography at the Library of Congress in Washington, will represent the American Geographical Society at the one-hundredth anniversary of the Royal Geographical Society in London in October.

DR. JOHN FARQUHAR FULTON, JR., of Oxford University, has been appointed Sterling professor of physiology at Yale University. Dr. J. G. Dusser de Barenne, formerly professor of physiology at the University of Utrecht and neurologist at St. Antonious Hospital, has been appointed professor of physiology.

DR. JOHN M. THOMAS, president of Rutgers University since 1925, will resign soon to become a vice-president of the National Life Insurance Company of Montpelier, Vt.

MR. JULIUS ROSENWALD, founder of the Museum of Science and Industry, at Chicago, is the recipient of the golden ring of the museum presented by the government of the Free State of Bavaria. Consul General H. F. Simon presented the ring to Mr. Rosenwald on behalf of the Bavarian Ministry of Education and Culture.

THE British Institution of Civil Engineers has awarded Telford Gold Medals to Messrs. David Anderson and B. B. Haskew and a Watt Gold Medal to Mr. A. E. L. Chorlton.

THE Alvarenga Prize of the College of Physicians of Philadelphia has been awarded to Dr. H. A. Harris, assistant professor of anatomy at the University College, London, for an essay entitled "Cod-liver Oil and the Vitamins in Relation to Bone Growth and Rickets."

THE following appointments have recently been announced by Princeton University: Dr. Eugene Pacsu, formerly a member of the faculty of the University of Budapest, has become assistant professor of chemistry; Dr. Edward U. Condon, formerly professor of theoretical physics at the University of Minnesota, has become associate professor of physics; Lewis F. Moody, prominent industrial engineer and a former member of the faculty of the University of Pennsylvania and of Rensselaer Polytechnic Institute, has become professor of hydraulic engineering; Clyde Whipple, of the Brooklyn Polytechnic Institute, is visiting associate professor of engineering.

DR. ROBERT KEITH CANNAN, of the University of London, has been appointed professor of chemistry at the medical college, New York University.

DR. HARRY G. PARKER, formerly of William Jewell College, has been appointed professor and head of the department of chemistry at Park College.

THE president of Union College announces the following additions to the faculty: Vladimir Rojansky, associate professor of physics; Russell A. Hall, assistant professor of civil engineering, and Egbert K. Bacon, instructor in chemistry.

AMONG the more important appointments at the University of New Hampshire are: Dr. James A. Funkhouser, assistant professor of chemistry, recently instructor in organic chemistry at Ohio State University, and Charles O. Dawson, recently employed on topographic survey work for airports in St. Louis and in Pennsylvania, instructor in civil engineering.

PROFESSOR DUGALD C. JACKSON, JR., formerly head of the department of mechanical and electrical engineering in the Speed Scientific School of the University of Louisville, has been appointed head of the department of electrical engineering in the University of Kansas.

THE following additions will be made to the faculty of the department of psychology at the University of Kentucky: Dr. Martin M. White, assistant professor; Dr. Henry Beaumont, executive secretary of student personnel service; Dr. Graham B. Dimmick, in charge of advanced courses, and Mr. Edward Newbury, instructor. They replace Dr. Paul L. Boynton, Dr. Gardner C. Bassett and Dr. James L. Graham, who have accepted positions at the George Peabody College for Teachers, Gettysburg College and Lehigh University, respectively.

DR. OSCAR EDWARD HERTZBERG, formerly professor of educational psychology in the Colorado State

Teachers College at Greeley, has accepted a position as head of the new department of educational psychology at the New York State Teachers College at Buffalo.

LEIF VERNER, formerly assistant professor of horticulture at the University of Idaho, has been appointed assistant professor of horticulture, assistant horticulturist and extension horticulturist at the West Virginia Agricultural Experiment Station. G. Gordon Pohlman, formerly assistant in agricultural chemistry at the University of Idaho, has been appointed assistant professor of agronomy and assistant agronomist. French M. Hyre, assistant county agent of Greenbrier County, has been appointed an assistant in farm economics. He will conduct the field work in the study of farm cooperatives of West Virginia in cooperation with the Federal Farm Board.

THE following appointments have been made at the University of Wisconsin: Edward M. Searles, assistant professor in economic entomology; Edward W. Azpell, instructor in steam and gas engineering; William R. Birnbaum, assistant in anatomy, and Louis Pruess, research assistant in agricultural bacteriology.

WE have been notified by George I. Cochran, president of the board of trustees of the University of Southern California, of the following additions to the faculty of the university. Appointments in the school of medicine are as follows: Dr. Daniel B. MacCallum, assistant professor of anatomy; Dr. Howard F. West, clinical professor of medicine; Dr. John C. Ruddock, Dr. Bertrand Smith, Dr. Arthur S. Granger and Dr. Roy E. Thomas, assistant clinical professors of medicine. Additions to the College of Letters, Arts and Sciences, are: Dr. Donald H. Loughbridge, physics; E. L. Bikerbike, J. E. Lawrence and Antonio Gandara, chemistry; Dorothy Fox, zoology; Dr. W. B. McDougall, botany; Thelma Littrell, mathematics; and the following in the department of physics-optics: Dr. Elmer R. Jones, supervisor of refraction laboratory; W. B. Clark, Dr. J. C. Goodsell, Dr. Arthur E. Hoare, Carrie B. Hooker, Dr. Ernest A. Hutchinson, Percy C. Kinney, Dr. Harry J. Hoare, and Leslie W. Scown, lecturers. In the College of Engineering Nathan C. Clark has been appointed instructor in electrical engineering; A. E. Stevens, instructor in general engineering, and James M. Shoemaker, lecturer in aeronautical engineering.

DR. CHARLES SCOTT BERRY, professor of educational psychology at the University of Michigan and consultant in special education for the Detroit public schools, has been appointed to the staff of the state department of education of Ohio in the newly created office of consultant in the education of the mentally handicapped.

THE appointment of Francis X. Schumacher as chief of the section of forest measurements in the Forest Service, U. S. Department of Agriculture, has been announced by R. Y. Stuart, chief forester. Mr. Schumacher, who has been teaching forestry in the University of California, will assume his new duties in Washington on October 1. He will succeed V. A. Clements, who will take up duties at the California Forest Experiment Station.

DR. MAX M. ELLIS, professor of physiology in the school of medicine of the University of Missouri, has been appointed to a responsible directive post as an investigator in the U. S. Bureau of Fisheries. While the fish cultural investigations now conducted at Fairport will still remain under the direction of Dr. H. S. Davis, the biological activities of the station will be supervised by Dr. Ellis.

DR. AUSTIN M. CRAVATH, Dr. John H. Findlay and Dr. Charles A. Swartz have been added to the staff of the research department of the Union Switch and Signal Company at Swissvale, Pa.

PROFESSOR DR. KEIJIRO ASO, of the Tokyo Imperial University, a well-known agricultural chemist who was one of the early students of Professor Oscar Loew and who was an official delegate to the International Congress of Soil Science which was held in Russia last July, will visit the United States in October on his way back to Japan. He will lecture at several places while he is here.

DR. EMILE HOLMAN, professor of surgery in the school of medicine of Stanford University, San Francisco, has been granted leave of absence during the autumn quarter to serve as visiting professor of surgery in Peiping Union Medical College, Peiping, China. During August, Dr. Holman visited Japan and gave lectures and clinics at the Severance Union Medical College, Seoul, Korea.

FATHER STEIN, S.J., has been named as director of the Vatican astronomical observatory. He succeeds the late Father John George Hagen.

THE Society of American Bacteriologists will hold its annual meeting under the presidency of Professor S. Bayne-Jones at the Massachusetts Institute of Technology from December 29 to 31, 1930. Dr. Barnett Cohen, of the Johns Hopkins School of Medicine, is in charge of the program.

THE regular annual two-day meeting and conference of the committee on electrical insulation of the division of engineering and industrial research of the National Research Council will be held on November 7 and 8, 1930, at the Bureau of Standards, Washington, D. C. The meeting will include three technical sessions at which eighteen informal papers reporting

current progress in dielectric and insulation research will be presented. On Friday evening, November 7, there will be a subscription dinner, followed by an illustrated lecture by a prominent physicist on recent advances in dielectric theory. A complete statement of the program will be announced shortly. Dr. J. B. Whitehead is chairman of the committee.

THE board of canvassers of the American Pharmaceutical Association, composed of T. C. Marshall, J. B. Pendergrast and Sinclair Jacobs, announce the election of the following for officers of the association: *President,* Walter D. Adams, Forney, Texas; *first vice-president,* J. G. Beard, Chapel Hill, N. C.; *second vice-president,* J. W. Dargavel, Minneapolis, Minn.; *members of the council* (for three years), H. A. B. Dunning, Baltimore, Md.; S. L. Hilton, Washington, D. C.; Ambrose Hunsberger, Philadelphia, Pa. These officers will be installed at the next annual meeting of the association which will be held in Miami, Florida, from July 28 to August 1, 1931. Mr. G. H. Grommet, who has been elected local secretary, is also secretary of the local committee on arrangements of which J. K. Klemmer is chairman and I. Clif. Smith is treasurer. The 1932 meeting will be held in Toronto, Canada, and will be a joint meeting with the Canadian Pharmaceutical Association.

THE National Association for Savings and Economy, of Istanbul, Turkey, will hold a farm congress on January 5, 1931, to determine the needs of the agriculturists.

A THREE-DAY conference of delegates from New South Wales agricultural societies and kindred organizations has been held at Sydney, Australia.

THE U. S. Civil Service Commission announces an open competitive examination to fill the position of senior geophysicist in the Bureau of Mines, Department of Commerce, for duty at Baltimore, Md. Applications must be on file with the U. S. Civil Service Commission at Washington, D. C., not later than October 22, 1930. Competitors will not be required to report for examination at any place, but will be rated on the subjects of education and experience, and on publications, reports or a thesis. Applicants must have been graduated with a degree from a college or university of recognized standing. Applicants must also have had certain additional experience or education. Full information may be obtained from the U. S. Civil Service Commission, Washington, D. C., or from the secretary of the U. S. Civil Service Board of Examiners at the post office or customhouse in any city.

THE Chemical Foundation of New York has given $100,000 to the government to endow a fellowship in the newly established National Institute of Public Health for research in the chemical industry. W. W. Buffum, general manager and treasurer of the foundation, presented the contribution to Andrew W. Mellon, Secretary of the Treasury. Francis P. Garvan, former alien property custodian, is president of the foundation.

THE Bouisson-Bertrand Institute, at Montpellier, France, has been authorized by the government to accept an annual subsidy of $10,000 from the Rockefeller Foundation. The money will be spent upon research into the cause and if possible promote the cure of Mediterranean fever, also known as Maltese fever.

AT the recent commencement exercises of the department of anatomy, portraits of seven of its former and present faculty members were presented to Western Reserve University School of Medicine: Drs. George W. Crile, Roger G. Perkins, Isaac Newton Himes, Charles F. Hoover, Frank Emory Bunts, Carl A. Hamann and George Neil Stewart.

THE list of British civil list pensions for the year ending March 31 last includes £90 to Mrs. Maude Mary Buckman, in recognition of the services rendered by her husband, the late Mr. Sydney Savory Buckman, in the sphere of geology, and £70 to Miss Katherine Mary Lovell Gamgee, in recognition of the services rendered by her father, the late Professor Gamgee, to medicine and physiology, and of her work in connection with public health.

DR. OWEN H. WANGENSTEEN, of the University of Minnesota Medical School, has received a $600 grant from the committee on scientific research of the American Medical Association for the continuance of his studies on intestinal obstruction.

THE Oxford University Press has arranged to continue *The Quarterly Journal of Mathematics* and *The Messenger of Mathematics* as a single journal, to be called *The Quarterly Journal of Mathematics* (Oxford Series). The editors will be T. W. Chaundy, E. G. C. Poole and W. L. Ferrar.

AN intensive and exhaustive study of Pennsylvania anthracite coal will be begun at once in three important universities, according to announcement made to-day by Noah H. Swayne, executive director of the Anthracite Institute. By arrangement with Lehigh University, Professor Homer G. Turner, assistant professor of mineralogy, has been appointed director of anthracite research and will devote much of his time during the next few years to that work.

SEVERAL hundred specimens of plants of the coffee family, sent to the Field Museum of Natural History

for study by the Botanical Garden of Leningrad, have been determined by Associate Curator Paul C. Standley, of the botanical staff of the Field Museum. Included were many specimens collected more than one hundred years ago and some obtained by the French botanist Aublet, who published in 1775 the first important work relating to the plants of South America. The Botanical Garden of Leningrad also sent to the museum in exchange more than one hundred plants of the same family, collected in Brazil by the well-known botanist Riedel and of great historical importance.

DISCUSSION

EUPHANY

IN the current number of the *British Journal of Psychology,* Professor T. A. Pear proposes to introduce the term "euphasia" to designate "the ability for deliberate and adequate statement of fact." One recognizes at once the great need for a technical term for this concept, but the term "euphasia" is unavoidably associated with terms of the same root in mental pathology, such as aphasia and disphasia. To avoid this, I wish to substitute the word "euphany" with its legitimate adjective "euphanious," the term being derived from the Greek word *phaino* which means "to say," "to reveal" or "to make clear," strengthened by the prefix "eu."

The term "euphany" may, therefore, be defined in terms of two concepts, namely, deliberation and adequacy of statement. Psychologically, deliberation involves a clarifying of percepts and concepts involved; abstraction in the form of clearing the ground by reviewing upon critical evidence all the plausible alternatives; generalization in which the issue is made sharp and clear by rejection of irrelevant issues; the recognition of meaning in the establishment of the relevancy of the clarified concept, and finally, decision which results in the expressed judgment or act. The term "adequate" merely reenforces this procedure by applying it to the one issue in hand.

The need for this word is felt, particularly in the statement of the goal of higher education and in the evaluation of progress toward this goal, as euphany is the principal objective of training in scholarship and the power of expression. The end of all science is classification, and euphany is the capacity for adhering rigidly and deliberately to classified concepts. In it the educator should set a model. To say that speech or writing is euphanious is to pay it a high and specific compliment.

C. E. SEASHORE

UNIVERSITY OF IOWA

NOMENCLATURE

MUCH of our discussion about nomenclature is apt to be beside the point, as very few workers have a conception of the enormous task confronting the systematists. The number of insect species living in the world at the present time has been variously estimated at from 1,000,000 to 10,000,000, and one person's guess is as good as another's. An even better estimate may be secured by taking a census of a smaller group. I have been interested during the last twenty years in making an index to the literature dealing with the insects of the order *Homoptera,* families—Cicadidae, Membracidae, Cercopidae, Cicadellidae (Jassidae) and Fulgoridae. This index now occupies one hundred thirty-two 3 x 5 drawers in my office. A couple of stenographers, an assistant and I are too busy in our spare moments indexing the new literature as it is published to count the number of cards in this index, but making a rough and ready estimate, there are about 150,000 references to about 30,000 species distributed in 5,000 genera. This is a small order of insects, and it is doubtful if considering the world as a whole we know more than one third of the species. The European fauna has been fairly well studied, so has that of North America, north of Mexico; but Mexico, Central America, the West Indies, South America, Africa, Asia, the East Indies and Australia have barely been touched. I am bold enough to predict (because I will be dead and this note will be forgotten long before the task is completed) that the discovery of the remaining species will change our concepts of things nomenclatorial more than they have been changed during the past 172 years. Yet, Linnaeus described in this group of insects in his famous Tenth Edition 1 genus and 42 species! In spite of these facts we hear on every side a plea for the return to the Linnean concept of genera and stability in nomenclature. What kind of a genus would it be with 100,000 or even 30,000 species in it? And how can there be any stability when only about one third of our territory is known? Why expect stability in anything? Even the material universe around us is not stable. Thirty years ago as a student I was told that the atom was the ultimate particle of matter beyond which there was nothing; yet to-day we float in a sea of electrons and protons. And only day before yesterday I listened to a physicist lecture on the wave theory of matter. No! There will be growth in our ideas of taxonomy and systematics as long as there are taxonomists and systematists.

In the Homoptera, Linnaeus knew nothing about wing venation, genitalia and other morphological

characters. But to-day no careful student would think of describing genera and species in this group without careful study of these characters. What of the future? Just as important characters await discovery, most, if not all, of our present concepts of genera and species will fade away before this broader knowledge like mist before the rising sun. In talking to some zoologists it seems to me that their conception of stability consists of a desire for the retention of the names that they learned, some of them 60, some 40, some 20 and some 10 years ago.

I remarked to a friend the other day that the whole thing reminded me of the embarrassment that we are sometimes confronted with in these days of easy divorce. We can never be sure whether the lady we are talking to is Mrs. Smith or Mrs. Jones, but we can be sure that it is the same person we knew for a long time as Mrs. Johnson. New names are embarrassing and confusing, but the true systematist can offer no escape from this confusion.

There is another idea prevalent in the minds of many biologists that needs to be corrected. For want of a better name I shall call this the pill-box in nomenclature. It runs something like this. If our conception of an animal fits a certain size pill-box it is a species; if it fits a larger box it is a genus. All that remains is to fit the animals in their appropriate boxes. All systematics degenerates, therefore, in the minds of many biologists to a kindergarten game of fitting triangles, squares, circles, *et cetera,* into appropriate openings. But the matter is hardly as simple as this. No one has defined the terms, genera and species. Concepts, especially concepts as varied as these, do not lend themselves to being crammed into pill-boxes. These objects that we call species are about as complex by comparison as the mosaic on the stairway of the Library of Congress. And it is, therefore, a little difficult to fit these complicated patterns into the appropriate openings in the general scheme of things. Stability won't do it. Stability simply puts many a square peg in a round hole and *vice versa.*

Dr. Gleason's two principles[1] won't do it, for no group of more than two systematists would ever agree as to what constituted a forgotten or nearly forgotten name. For the lines separating names in use, nearly forgotten and forgotten are as non-existent as other lines in nature; they are man made and, like all other boundaries, subject to shifts. Hence, good-bye stability. The second principle, that of making no changes unless the author believes he is thereby adding to the sum total of human knowledge, may be needed in certain fields of science, but in systematic zoology—never. All systematic zoologists (even the mythical Dr. X who discovered that the name of the cow should be *Equus caballus* and the name of the horse should be *Bos taurus*) know that they are adding to the sum total of human . . . (excuse me, I almost wrote confusion) knowledge.

[1] SCIENCE, 71: 459.

Z. P. METCALF

NORTH CAROLINA STATE COLLEGE

ADMIRAL WALKER'S APPRECIATION OF THE WORK OF COLONEL GORGAS

MY attention has to-day been called to an article in SCIENCE for May 30, 1930, written by Dr. John F. Stevens, formerly chief engineer of the Panama Canal, which is couched in such vague terms that I feel he may be doing an unintentional injustice to my father, Rear Admiral John Grimes Walker, the first chairman of the Panama Canal Commission.

Dr. Stevens writes of "the condition of affairs on the isthmus during a part of the year 1905" and speaks of his arrival there in July of that year and what he then found to be the situation—"the then chairman of the Isthmian Canal Commission accompanied me on my first visit to the isthmus, remaining there but five days, as the situation did not appeal to him. . . . Neither the Governor nor the chairman had the least faith in the efficacy of the mosquito theory—at least they so emphatically advised me at once, and their actions confirmed their words."

As the commission of which Admiral Walker was chairman resigned in a body on March 30, 1905, these remarks evidently do not apply to him but to his successor in office; as, however, few people are likely to remember the exact date of the formation of the new commission and as Admiral Walker's name has been long and widely connected, not only with the Panama Canal Commission but also with the preceding commissions which carried out all the vitally important preliminary investigations and studies, I feel that Dr. Stevens' omission of all names in making the foregoing statements is extremely misleading.

Admiral Walker had followed with deep interest Colonel Gorgas' wonderful work in ridding Cuba from yellow fever and was so firmly convinced of its value that when President Roosevelt sent for him and offered him the chairmanship of the commission being formed to build the canal the first condition he made was that Colonel Gorgas should be put in charge of the medical and sanitary work on the isthmus. As to the reference to "the then chairman's" stay of only five days on the isthmus "as the situation did not appeal to him"—to any one who knew Admiral Walker this in itself would prove that Dr. Stevens was not referring to him, for he was on the isthmus

many times in connection with canal matters, spending months at a time there, often living in tents in the jungle in order to know at first hand the problems along the proposed routes.

I am collecting material for a sketch of my father, but as I sail for Europe this week I have put all papers in storage and can at present only state the facts as known to myself, the only bit of corroboration at hand being a sentence from a report to Hon. William H. Taft, Secretary of War, dated March 16, 1905, as follows: "The Commission . . . moreover feels itself under obligation not only to provide screens for all buildings owned or controlled by it, but would like to see all buildings where screens would be of any service suitably screened."

I should be glad if you could find space for this letter in order to correct any possible misconception of Dr. Stevens' meaning.

FRANCES PICKERING THOMAS

BOSTON, MASS.

SCIENTIFIC BOOKS

Die Phylogenie der Pflanzen. DR. WALTER ZIMMERMAN, University of Tübingen. Jena, Verlag von Gustav Fischer, 1930.

THIS is one of the comprehensive works which are a feature of German scientific activity at the present time. It deals with the subject of the evolution of plants, particularly the higher plants, in a thorough fashion from the standpoints not only of morphology, anatomy and development, but also what is rarer, from the standpoint of fossil plants. It is dedicated to Graf Zu Solms-Laubach.

The volume consists of about 450 pages, only some 50 of which are devoted to the Thallophytes. This apparent discrimination against the lower forms arises out of the historical basis of the volume under consideration. Since the record of the lower forms is extremely imperfect, they naturally do not supply abundant material for this volume. About 400 pages are given over to the consideration of the Cormophyta. About 50 pages are devoted to general problems such as the structure and combination of organs, the differentiation of organs, the development and differentiation of the stele and wood, and to reproduction. Under the Cormophyta are included the Bryophyta, which are very briefly considered. Following is the division Psilophyta, to which the author appends the Asterophyta and Psilotales. The third division comprises the Lycopsida, including the forms which are now clearly recognized as coming under this comprehensive heading. The fourth division comprises the Articulata, which are equivalent to Dr. Scott's Sphenopsida. Under this group are arranged the Hyeniales, Pseudoborniales, Sphenophyllales, Cheirostrobales and Equisetales, which are divided into three families, the Asterocalamitaceae, Calamitaceae and Equisetaceae. Next comes the division Pteropsida, including the Filicinae—Primofilices, Eusporangiatae, Osmundales, Leptosporangiatae and Hydropterides. Follow the Gymnospermae, including Pteridospermeae, Cycadophyta, Ginkgophyta, Cordaitales, Coniferae and Gnetales. This chapter is most interesting because it correlates to a large degree the anatomical, morphological and paleobotanical work done in recent years. The treatment of the Conifers indicates the confusion of opinion which still prevails in that field. The botanical world will await with keen interest the complete publication of the investigations and views of Florin and Walton in this important field, since the Conifers, on account of their long duration in geological time and present good state of development, constitute the most important of all biological documents from the evolutionary standpoint. The unchallenged antiquity of the araucarian Conifers no longer prevails and the next few years are likely to see very fundamental changes in this important field. The third division of Pteropsida comprises the Angiosperms and reflects our doubts and difficulties regarding this extremely important group, concerning the origin of which we have scarcely passed beyond Darwin's statement of horrible mystery. Naturally the difficulties which beset the phylogenetic interpretation of the Angiosperms are very great in view of our almost complete ignorance of their early development.

Another division of the volume deals with the history of floras in which the Algae, the Pteridophyta, Gymnosperms and Angiosperms mark quite satisfactorily the main geological periods. A third main division of the volume deals with general historical laws. Under this heading are discussed the development of characters, ascending and descending evolution, the law of irreversibility, polyphyletic, parallel and convergent evolution, correlative evolution, the biogenetic law, reversions and teratological developments in relation to phylogeny.

The second main division of the volume deals with the so-called causal analysis of phylogeny. Under this heading the author deals with phylogeny as a physiological process with continuous and discontinuous variation and the development of characters suited to the environment. Further he discusses the Lamarckian and Darwinian attitudes towards evolu-

tion, calling attention to the essentially Lamarckian attitude of the genetical group at the present time. He further deals with the difficult subject of the inheritance of acquired characters, a field which has recently assumed renewed prominence in connection with experimental use of radiations. There follows a discussion of the essential principles of Darwinism under the headings of the selective action of the struggle for existence, the accumulation of mutations (variations), the origin of mutations (variations). Next comes a discussion of the limitations of Darwinism and of the problem of the protean character of organic matter. These various discussions end with a summary of the most important results of phylogenetic analysis.

Although the volume is of moderate size, it contains a very large amount of information and is most attractively and comprehensively illustrated. It will be of great value to all students of botanical science who can read the German language with any degree of ease.

E. C. Jeffrey

Botanical Department,
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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD FOR MAKING A BIBLIOGRAPHY

Scientific workers generally agree that a bibliography is an essential for good research.[1] Bibliochresis is the first and a fundamental step in the natural approach to a new problem. In many cases there are regularly maintained bibliographies which are available for use, and even though they may be one or two years in arrears, the workers find it possible to supply the lacking material with a few hours' search of the leading publications and annual reports. For example, the bibliographies of North American geology, edited by Nickles and published by the U. S. Geological Survey, have covered the literature in this field for the period since 1785. As specialties within a field develop it has been found necessary in some cases to compile a bibliography for that branch of the science and to keep it up to date by the periodic publication of new lists. Many science departments or individuals of various universities and colleges find it desirable to compile bibliographies which are so arranged that they supplement the published reference lists if such exist. This has been the case in the division of sedimentation of the department of geology at the State University of Iowa. The graduate students as well as the members of the staff interested in this field of geology contribute regularly to this file. During the last two years the writer has been active in compiling a bibliography pertaining especially to the petrography of sediments. The plan used is submitted here in the hope that others may find it helpful, or will make for improvement.

The references which include the complete data regularly given in bibliographies are typed on a fanfold form in triplicate, with eight sets of cards in series. An 88-pound white ledger Scotch linen paper has been found most desirable. The paper used is thin enough to make good carbon copies, takes little space in the file drawers and is tough and stiff enough to withstand harder use than the average grade 3 x 5 file card. Sheets 24 x 15 inches are perforated accurately so as to make twenty-four 3 x 5 inch cards in three vertical rows of eight each. The 5-inch dimension of the card times three cards utilizes the 15-inch dimension of the original sheet, and the 3-inch dimension of the eight cards fills the 24-inch dimension. When ready for use the large sheets are folded along the two 24-inch perforations making a triplicate form 5 inches wide and 24 inches long. Carbon copying sheets 5 x 24 inches are used. This makes it possible to type eight references in triplicate with the one operation of folding, placing carbon paper and inserting in typewriter. When the typing is completed the cards are torn apart, or cut along the perforations with a large knife paper trimmer, keeping the three copies of the reference together. When ready to file, the three cards are torn along the perforations and distributed in any manner desired. The advantage of three copies of the same reference, and the speed a good typist can make in copying a large number of references when he has only to insert a new set of forms for every eight bibliography references, more than pay the small cost of the forms.

The same type of triplicate fan-fold form is used in a 5 x 8 inch size, seven in vertical series, for a file of definitions of sedimentary rocks. In fact, the general idea was worked out first when the subcommittee on the classification of sedimentary rocks, of the committee on sedimentation, National Research Council, wished to make three identical sets of rock definitions.

In actual practice in this department, the graduate students interested in sedimentary petrography and the writer in his own research accumulate the bibliographical data on whatever type of paper, card or

[1] See W. A. Hamor and L. W. Bass, "Bibliochresis," Science, n. s., 71: 375–8, April 11, 1930.

other arrangement is most convenient at the time. When a hundred or more references are on hand they are given to a typist who makes the copies on the form described and arranges the wording according to a uniform plan. Often the bibliography maker writes a short abstract of the article, or comments on its most useful information, and these statements of from 75 to 125 words are copied on the cards.

The system of filing used by the writer is an attempt to place the cards so they will be most readily found when looking through the index for particular articles or when making a study of a specific subject. The first or original card of each set is placed in a general file arranged alphabetically by authors; the second card (a carbon copy) is placed in its proper alphabetical order according to the type of rock or mineral or texture described; the third card (second carbon copy) is placed in a miscellaneous group, arranged alphabetically, under such headings as "chemical analyses," "environments of deposition" (with subdivisions as lakes, rivers, marine, littoral, swamp, etc.), "laboratory methods," "mineral analyses" and many others. Oftentimes the third card is placed under a separate subheading of the division which contains the second card. For instance, the cards covering the article by Takahashi, on the "Significance of Micro-crystals of Carbonates in Bituminous Shales," would be distributed (1) in "T" of authors' file, (2) in "shales" of the rock division of the file and (3) in "carbonates" in the same division. Another article, by Kindle, "A Comparative Study of Different Types of Thermal Stratification in Lakes and their Influence on the Formation of Marl," would be found by looking in the author index or under "marl" of the rock division or under "lakes" of the environment of deposition class of the miscellaneous division. Often the word used for filing purposes, or the method of classification does not appear in the title of the article but will be given in the abstract of the article at the bottom of the card. When such is the case, it has been found convenient to underline the word or clew to classification with red pencil. Cards for the article by Ross on "Altered Paleozoic Volcanic Materials and their Recognition" would be found in the author index, one under volcanic rocks and the third one in the mineral analyses class, this being an important feature of the article.

The writer recognizes that the brief description does not show clearly how every type of reference would be filed, or that the method is entirely foolproof, but he knows from experience that he can usually find a bibliographical reference in a short time, if it is in the file, without the delay of going through an authors' index.

A. C. TESTER

STATE UNIVERSITY OF IOWA

TEST PAPERS FOR DETECTING MAGNESIUM

A CONVENIENT method for carrying out the new organic test for magnesium is by means of a spot reaction on filter paper impregnated with the reagent. The test papers may be prepared as follows. White filter paper is immersed in a 0.01 per cent. solution of para-nitrobenzene-azo-resorcinol[1] (ortho, para-dihydroxy-azo-para-nitrobenzene) in alcohol and hung up to dry. When dry cut into pieces of about four square inches and preserve in amber bottles. To perform the test, one drop of the slightly acid solution to be tested is placed in the center of the test paper and allowed to dry. Immerse paper in a dilute sodium hydroxide solution (about 1 per cent.). In the presence of magnesium a blue spot will show in a reddish field. If the test drop contained a large amount of acid the spot will first be yellow. The reaction as performed is sensitive to about 0.005 milligrams of magnesium (one drop of a solution containing 0.1 milligram of magnesium per cc). The limitations on this procedure are the same as those noted before,[2] nickel and cobalt giving similar colored spots and large amounts of ammonium salts and organic matter reducing the sensitivity.

IRWIN STONE

NEW YORK, N. Y.

SPECIAL ARTICLES

LIVING MICRO-ORGANISMS IN THE AIR OF THE ARID SOUTHWEST

NUMEROUS living micro-organisms are present at times in the air in southern Arizona. Recently the writer exposed from aeroplanes sterile agar plates and spore traps during flights primarily intended to afford information concerning the movement of the spores of wheat rusts. Two agars were used: Nutrient, pH 7.2, and potato, pH 6.8. Exposures were uniformly two minutes in length. Some of the results are given in the following table.

No spores of wheat rust were found, but further trials may discover them. Among the fungi were species of Aspergillus and Penicillium, Macrosporium, Alternaria, Cladosporium and one yeast. White and

[1] Purchasable from Eastman Kodak Company, Rochester, New York, or may be prepared by detailed method given by Stone, *Chem.-Analyst*, 19: 6, May, 1930.

[2] Riugh, *J. A. C. S.*, 51: 1456, 1929; Engel, *ibid.*, 52: 1812, 1930.

April 11, 1930

Plane, Fokker, trimotor; weather clear, sunny; surface air temperature, 28° C.; air temperature aloft, 24° C. at 5,000 feet and 22° C. at 5,800 feet; surface wind S., 5.5 miles; wind at 6,000 feet S.S.E., 8 miles.

Plate no.	Medium	Altitude above sea-level, ft.	Speed of plane, M.P.H.	Number of colonies		
				Fungi	Bacteria	Total
1	Pot.	5,500		19	222	241
2	Nutr.	5,700	110–115	10	103	113
3						
4	Nutr.	5,500–5,800		11	165	176
5	Pot.	5,200	120	25	151	176
6	"	5,000	125	23	103	126
7	Nutr.	4,800–5,000		6	66	72
8	Pot.	4,300–4,500	115–120	20	43	63
9	"	2,300–1,500		38	158	196
		April 12, 1930				
	Same plane; weather clear, sunny, quiet.					
10	Nutr.	3,100–3,700	95–100	50	454	504
11	"	6,000–6,400	100–105	1	211	212
12	"	7,000–7,200	100–110	8	95	103

gray colonies of bacteria predominated, although there were numerous chromogens. The fungi and bacteria will be tested for pathogenicity on the most important economic plants of Arizona.

The viability of micro-organisms in arid regions has not been extensively studied, possibly because institutions of research usually are not located in or near deserts. On this subject the opinion is widely held that bacteria and fungi are quickly killed by the prevailing conditions of light, heat and dryness. No doubt the almost proverbial health of the native human inhabitants of arid regions has something to do with this belief, although their health is probably the result of the stimulating effect of outdoor life rather than of the absence of germs. At any rate, parasitic plant diseases are common, and bacteria and other micro-organisms are abundantly present.

The abundance of living organisms in surface dust and soil in Arizona has been shown by two investigators. In 1919 Miss Mary Estill,[1] now Professor M. E. Caldwell, isolated more than thirty species of bacteria from dust obtained in the streets of Tucson and adjacent country. Later the same investigator[2] showed that the bacterium of tuberculosis retained its virulence in dust, outdoors, for as long as seventy-two hours. Dr. Laetitia M. Snow[3] in 1926 studied the bacterial flora of wind-blown sand obtained near Tucson and isolated about eight times as many organisms as were later found to live in the wind-blown sand of dunes at Sandwich, Massachusetts.

That the micro-organisms in air ride on particles of dust has long been known. Dust and wind-blown sand carrying bacteria, fungal spores and even pieces of mycelia are lifted upward by the spiral "twisters" and the wind-storms of arid regions. Granted that the organisms remain alive during the aerial movement, the distance that they are carried becomes an important question. This will depend upon the height to which the dust and sand ascend as well as upon the air current. If the germ-laden particles reach the upper air currents the distance may be great. During the flights made by the writer, a maximum altitude of 7,200 feet above sea-level or 5,700 feet above the surface was attained and living bacteria found. Therefore dust must be lifted to that height. Redway[4] states that wind-blown dust rarely ascends over 2,000 feet. On the other hand, MacMahon,[5] an aviator, says of a South American trip, "On still another flight, while crossing the pampas, a sandstorm blowing 6,000 feet into the air forced us to fly blind for a time."

J. G. Brown

University of Arizona

THE RELATION OF THE THYROID AND PITUITARY GLANDS TO MOULTING IN TRITURUS VIRIDESCENS

Stopping of the periodic moult in *Triturus viridescens* can be brought about by extirpation of certain of the endocrine glands. For example,[1] thyroidectomy inhibits skin shedding, and animals lacking thyroids become gradually blacker and blacker as layer after layer of cornified cells is formed and not sloughed off. This reaction is usually noticeable within two weeks (depending somewhat on the temperature) and by four weeks is markedly evident. Hypophysectomy also causes a cessation of moulting, and the experiments done by two of the authors (Adams and Kuder) show that the pars anterior is the part intimately involved in this result. Removal of it alone produces the same effect (lack of moulting and

[1] Mary Howard Estill, master's thesis, University of Arizona.

[2] Mary Estill Caldwell, "Viability of Mycobacterium Tuberculosis in a Semi-arid Environment," *Jour. Infect. Dis.*, 37: 465–472, 1925.

[3] Laetitia M. Snow, "A Comparative Study of the Bacterial Flora of Wind-blown Soil: I. Arroyo Bank Soil, Tucson, Arizona," *Soil Sci.*, 21: 143–161, 1926; "A Comparative Study of the Bacterial Flora of Wind-blown soil: II. Atlantic Coast Sand Dunes, Sandwich, Massachusetts," *Soil Sci.*, 24: 39–48, 1927.

[4] Jacques W. Redway, "The Dust of the Upper Air," *Ecology*, 2: 104–109, 1921.

[5] Harold E. MacMahon, "Blazing New Trails," *Liberty Magazine*, p. 47, May 3, 1930.

[1] A. E. Adams and L. Richards, "The Effect of Thyroidectomy in *Triturus viridescens*," abstract, *Anat. Rec.*, 44: 222, 1929.

blackening of the animal as the layers of cornified skin remain in place) as removal of the whole gland.

The similarity of the appearance of the specimens of *Triturus viridescens* after thyroidectomy or hypophysectomy suggests that there may be some interdependence of these two glands in the control of the moulting process, and a series of experiments was devised to answer the following questions. (1) Does thyroid removal in itself cause the inhibition of moulting or does it affect the pituitary in some way so that it is a maladjustment on the part of the latter rather than absence of the former that is at the root of the difficulty? Or (2) does hypophysectomy in itself directly cause the inhibition or does its absence affect the thyroid in some way so that it is essentially an upset of the thyroid that is the real trouble?

The tests were made by grafting thyroid glands (in a few cases by injecting thyroxin) or pituitary glands (whole glands or pars anterior only) into (1) thyroidectomized, (2) hypophysectomized or (3) hypophysectomized-thyroidectomized animals, all of which had stopped moulting after the respective operations and were very definitely black with the piled up cornified epidermal layers. Briefly the results were as follows. Thyroid glands of normal animals transplanted into thyroidectomized or hypophysectomized or hypophysectomized-thyroidectomized animals will induce a complete moult of the many-layered cornified epidermis within a short time, usually as early as two days after the transplant. Transplantation of the thyroids of hypophysectomized animals into hypophysectomized or thyroidectomized animals will have the same effect. Injection of thyroxin or immersion in it will cause moulting in thyroidectomized animals, and injection is likewise efficacious in hypophysectomized ones, but it has not yet been tried on ones from which both glands have been removed. Pituitary glands (whole glands or anterior lobes) transplanted into thyroidectomized or hypophysectomized-thyroidectomized animals (ones from which the thyroids and pituitary had been removed simultaneously or from which the thyroid had been removed just prior to grafting) will not bring about the moult. (In a few cases thyroidectomized animals, which had blackened somewhat, moulted after pituitary grafts, but a careful search always revealed the presence of some thyroid follicles.) If thyroids are transplanted into these animals subsequently to the pituitary grafts, the animals shed their skins. Pituitary glands (whole glands or anterior lobes) transplanted into hypophysectomized animals will induce moulting within a few days.

This combination of results at once suggests that the key to the explanation of the inhibition of moulting lies primarily in the thyroid gland. Thyroid grafts are able to stimulate moulting in all the operated animals (thyroidectomized, hypophysectomized or hypophysectomized-thyroidectomized) because they supply the essential hormone, but pituitary grafts are able to do it only in hypophysectomized animals where the thyroids are still present and can be activated by such grafts. In the thyroidectomized animals an athyroid condition has been produced, and although cornification of the skin continues, sloughing is discontinued. In the hypophysectomized animals, a hypothyroid state (possibly a functional athyroidism) has been brought about by the removal of the pituitary gland (either whole gland or pars anterior only) and this hypothesis is supported by a histological study of the thyroids in such animals. Instead of the usual cuboidal cells bounding the follicle and a moderate amount of colloid within the follicle, the cells are flattened and a large amount of colloid distends the follicle. However, these thyroids contain the active hormone because when removed from hypophysectomized animals and retransplanted into the same animal, moulting occurs just as quickly (in two days) as if thyroids from normal animals had been used. Such thyroids also will cause moulting in thyroidectomized animals.

From these experiments it seems probable that the thyroid hormone is essential for the normal moulting mechanism and that the secretion of the anterior lobe of the pituitary in some way regulates the thyroid gland. A full account of these experiments will appear later.

A. Elizabeth Adams
Leah Richards
Alberta Kuder
Mount Holyoke College

BOOKS RECEIVED

Duncan, John C. *Astronomy.* Pp. xix + 435. 65 plates. 180 figures. Harper. $3.75.

Good, M. E. *Hear with Your Eyes.* Pp. viii + 41. 32 photographic illustrations. Appleton. $1.00.

Koppanyi, Theodore. *The Conquest of Life.* Pp. xi + 263. 55 illustrations. Appleton. $2.00.

MacDougal. *The Green Leaf:* Major Activities of Plants in Sunlight. Pp. 142. 22 illustrations. Appleton. $2.00.

Mathewson, Louis C., and John W. Young. *Elementary Theory of Finite Groups.* Pp. x + 165. Houghton Mifflin. $2.50.

Pulvermacher, William D., and Charles H. Vosburgh. *The World about Us.* Pp. v + 382. 288 figures. Heath. $1.60.

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